Desalination & Water Purification Technologies

Technical Information Document

Government of India

Department of Atomic Energy
Bhabha Atomic Research Centre
Chemical Engineering Group
Desalination Division
Trombay, Mumbai 400 085

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FOREWORD

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About 40 million people (over 75% are children) are affected by water borne diseases every year. Nearly six million children below 14 years of age suffer from fluorosis due to fluoride contamination in water. Arsenic is another dangerous contaminant in ground water. putting at risk more than 10 million people in the country. Bacteriological contamination, which leads to diarrhea, cholera, hepatitis etc., is at alert level in India. Contamination due to Iron, hardness and salinity in water are other major concern. Medical expenditure on water borne diseases is estimated to be Rs. 2400 crores annualy in the country.

The need for desalination and water purification is destined to grow in the coming years as the requirment for water increases. Bhabha Atomic Research Centre (BARC) has been engaged in R&D on desalination and water purification technologies for several years and has developed indigenous technologies wich are available for know-how transfer to interested parties.

I hope this technical information document will serve the purpose of creating awareness of and appreciation for desalination and water purification technologies, among the entrepreneurs, NGOs and other interested groups, so that safe drinking water can be made available to the needy population in a reliable, sustainable and affordable manner using the indigenous technologies and supplementing with market technologies in an accelerated manner on a significant scale. BARC would encourage entrepreneurs to come forward and make use of the indigenous know-how for wider deployment.

(R. K. Sinha)

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PREFACE

Early humans thought that the taste of the water determined its purity. The Sus'ruta Samhita, Sanskrit writings about medical concerns (2000 BC), gives evidence that water treatment may well be as ancient as humans are. The Greeks and Romans are well known for their elaborate water systems. These early water treatment professionals used a variety of methods to control taste and odor problems in their water supplies. A correlation between water quality and health was made, in mid- 19th century in London, when a decrease in cholera deaths epidemics were noticed where slow sand filters had been installed.

The World Health Organisation (WHO) has set international guidelines for drinking water. Almost all countries have drinking water quality regulations, often inspired by WHO guidelines. According to the United Nations, over 1.1 billion people are currently without safe drinking water. It is predicted that a significant fraction of the global population (over 3.5 billion people) will be living in areas facing severe water shortages by the year 2025. More than half of the world's hospital beds are occupied by patients suffering from water borne diseases. Many of these diseases can be prevented by providing safe drinking water. The United Nations General Assembly has proclaimed the years 2005-2015 as the International Decade for Action 'Water for Life'. Government of India has launched 'Bharat Nirman' Yojana which includes drinking water as an important programme. It is in this context, the role of desalination and water purification becomes very important.

Desalination of water is one of the key drivers under non-power applications of DAE program. Desalination Division, Bhabha Atomic Research Centre (BARC) has been engaged in R&D on various aspects of desalination and water purification technologies starting from basic research work to development and deployment efforts. Dedicated team of scientists and engineers have contributed substantially to the expertise gathered, technologies developed and know how generated in the research centre. The research work carried out has mainly focused on technological innovations, quality, reliability and commercialization potential of the product/ technology for deployment over large scale. State-of-the-art reliable technologies have been developed to address the growing need of good quality water for industries and human consumption.

We have acquired valuable experience on operation and trouble shooting of desalination and water purification plants and are equipped to provide consultancy to interested parties on design, installation, commissioning and operation of these systems. Such consultancies are provided after signing a Memorandum of Understanding (MoU). Several water technologies developed by Desalination Division have been transferred to private parties on non-exclusive basis.

We are thankful to all the scientists and engineers who came forward to share their expertise and information in the formulation of this Technical Information Document. This document would not have been materialised, but for the encouragement and support of Director BARC and Chairman AEC for water technologies.

The document is not intended to provide detailed technical information on various technologies, but is aimed to provide a glimpse of the technologies for the entrepreneurs, NGOs and other interested parties. The purpose of bringing out this technical document is to consolidate the work carried out by Desalination Division (BARC), so that deployment of such technologies could be accelerated through the participation of private entrepreneurs, NGOs and other interested groups.

(P.K. Tewari)
Head, Desalination Division

1. Introduction

The world's water consumption rate is doubling every 20 years, outpacing by two times the rate of population growth. The availability of good quality water is on the decline and water demand is on the rise. Worldwide availability of fresh water for industrial needs and human consumption is limited. Various industrial and developmental activities in recent times have resulted in increasing the pollution level and deteriorating the water quality. Water shortages and unreliable water quality are considered major obstacles to achieve sustainable development and improvement in the quality of life. The water demand in the country is increasing fast due to progressive increase in the demand of water for irrigation, rapid industrialization, population growth and improving life standards. The existing water resources are diminishing (i) due to unequal distribution of rain water and occasional drought, (ii) excessive exploitation of ground water sources and its insufficient recharge, (iii) deterioration of water quality due to the discharge of domestic and industrial effluents without adequate treatment. This is resulting into water stress/ scarcity. Country is currently passing through social and economic transition. The proportion of the population which is urban has doubled over the last thirty years (and is now about 30%), agriculture now accounts for about 25% of GDP and the economy has been growing at around 7-9% a year. Country has a highly seasonal pattern of rainfall, with 50% of precipitation falling in just 15 days and over 90% of river flows in just four months.

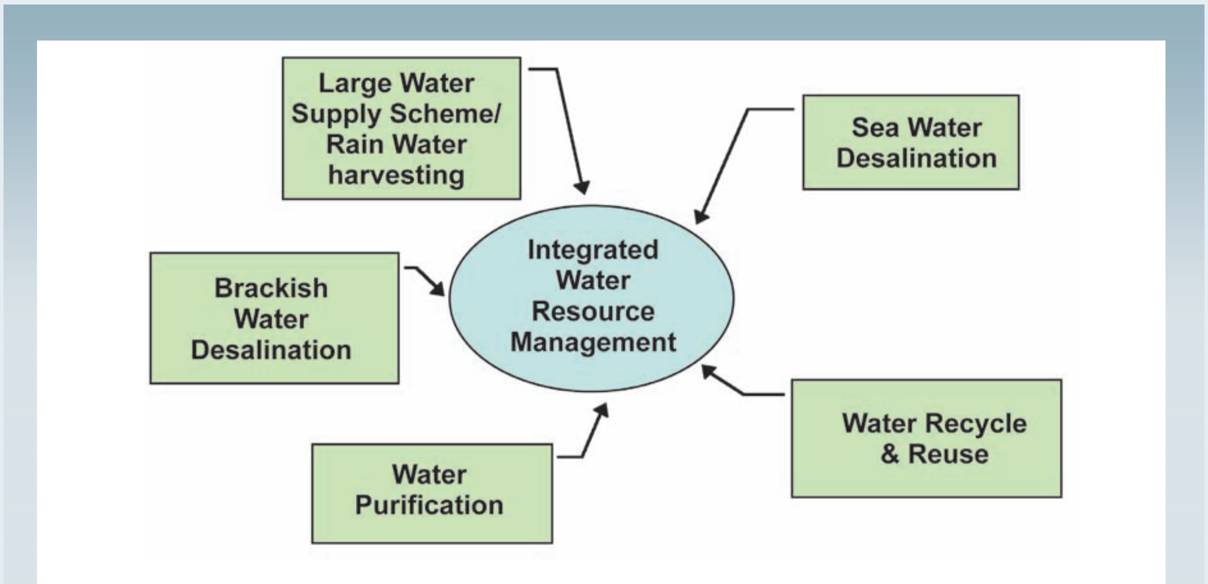
There are areas like Saurashtra and Kutch, Western Rajasthan and the coastal regions of Tamil Nadu etc. which face perennial water shortage. In addition, a large number of villages in different parts of the country are known to be suffering from excess salinity, fluoride, iron, arsenic and microbial contaminations of ground water. Desalination is recognized as a possible means to augment the water supply using natural resources for meeting the growing demand of water.

Seawater, brackish water and fresh water have different levels of salinity, which is often expressed by the total dissolved solids (TDS) concentration. Water is considered potable when its TDS is below 500 mg/L. Seawater has a TDS of about 35,000 mg/L and brackish water has a TDS between that of potable water and seawater. Waste water is another category containing dissolved salts mostly in the low brackish level. The reclaimed water from waste water can be used for irrigation, cooling water and other industrial applications. Since the projected industrial and irrigation requirements would be far exceeding that of domestic requirements, recycle and reuse of waste effluents apart from desalination make enormous sense for future water management.

A holistic approach is therefore required to be considered to deal with water problem. It includes:

- Seawater desalination in coastal areas
- Brackish water desalination
- Water purification
- Water reuse
- Rain water harvesting
- Water supply schemes

Desalination, water purification & water recovery/ reuse schemes are destined to play a major role and commercially viable indigenous technologies are thus required for deployment to suit local conditions.



Integrated Water Resource Management – A Holistic Approach

2. Desalination Technologies

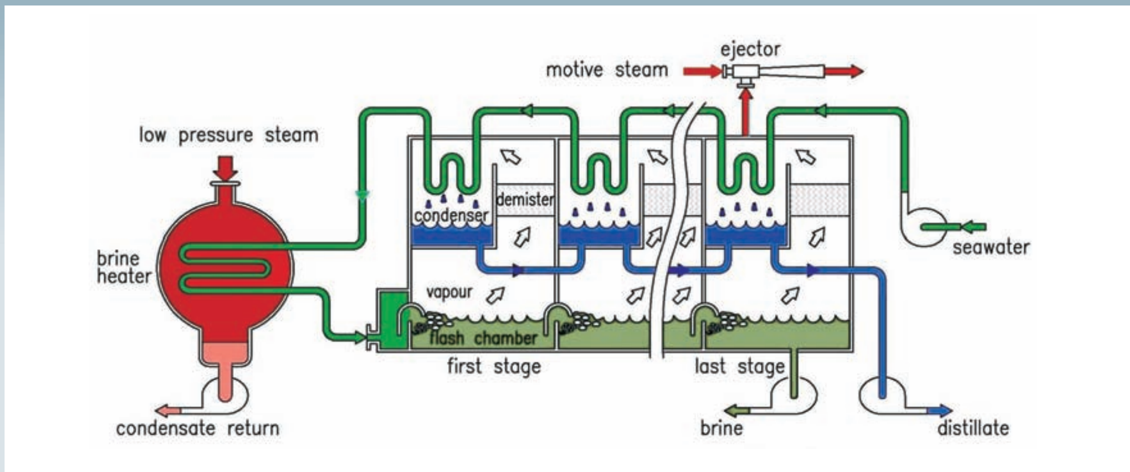
Desalination refers to the process by which pure water is recovered from saline water using different forms of energy. Saline water is classified as either brackish water or seawater depending on the salinity and water source. Desalination produces two streams - freshwater and a more concentrated stream (brine). The two main commercial desalination technologies are those based on thermal and membrane processes.

2.1. Thermal Desalination

Thermal processes, except freezing, mimic the natural process of producing rain. Saline water is heated, producing water vapour that in turn condenses to form distilled water. These processes include multi-stage flash (MSF), multiple-effect distillation (MED), vapour compression (VC) and low temperature evaporation (LTE). In all these processes, condensing steam is used to supply the latent heat needed to vapourize the water. Owing to their high-energy requirements, thermal processes are normally used for seawater desalination. Thermal processes are capable of producing high purity water and suited for industrial process applications. Thermal processes account for 55% of the total production and their unit capacities are higher compared to membrane processes.

2.1.1. Multi Stage Flash (MSF) Process

The basic principle involved in the MSF process is to heat the sea water to about 90– 120°C using the heat of condensation of the vapour produced and supplementing with external steam. The heated sea water is subsequently flashed in successive stages maintained at decreasing levels of pressure. The vapor produced is condensed and recovered as pure water. MSF can accept higher contaminant loading (suspended solids, heavy metals, oil, grease, COD, BOD etc.) in feed sea water. It is capable of producing distilled quality product water good for power plants, process industries and several other high purity applications.

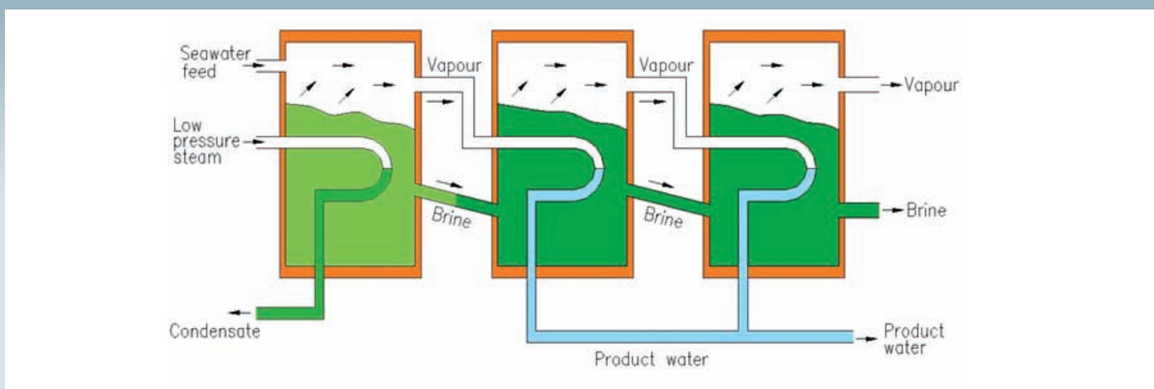


Schematic Diagram of Multi-Stage Flash (MSF) Process

2.1.2. Multi Effect Distillation (MED)

MED plant has two or more effects. Each effect operates at a successively lower temperature and pressure. The first effect is heated by low pressure steam (about 0.3 bar). Vapours are generated from the feed sea water in the first effect and directed to the second effect. Thus vapours from the previous effect serve as the heat source to the succeeding effect for evaporating the brine. Vapour from the last effect is condensed in the final condenser where sea water is used as the coolant. The vapour produced in each effect is passed through the demisters to next effect. It is condensed inside the tubes transferring the latent heat to the brine falling outside the tube enabling a portion of the brine to evaporate. Low temperature MED unit operates at about 65°C and therefore allows the use of cheaper materials of construction due to less scaling and corrosion problems. MED is capable of producing pure distilled water similar to MSF. The possibility of low temperature operation, low grade heat and waste heat utilization, low cooling water requirement and low energy consumption have made MED an attractive alternative in recent years for sea water desalination.

Efficiency of MED plant can be improved by adding a vapour compressor. Mechanical Vapour Compressor (MVC) or Thermal Vapour Compressor (TVC) is used for this purpose depending on site specific conditions.

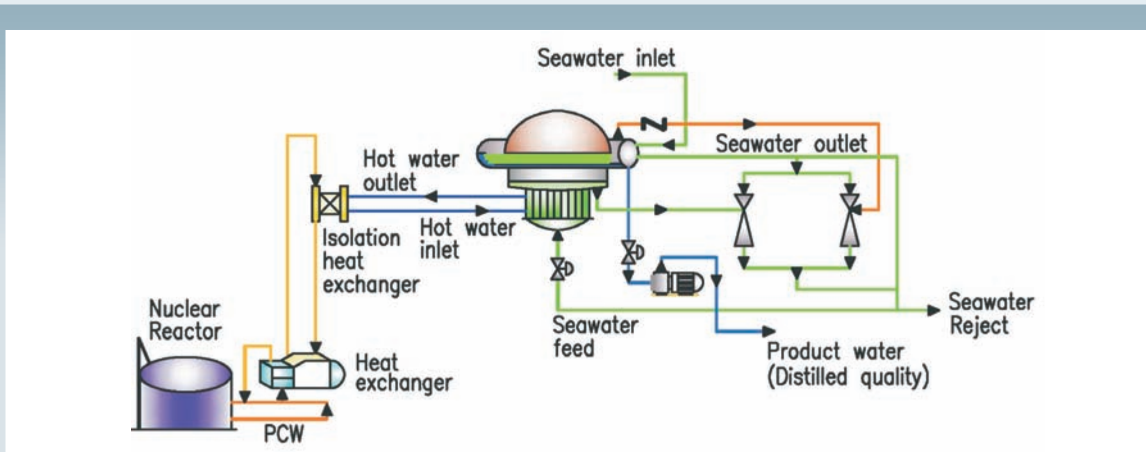


Schematic Diagram of Multi-Effect Distillation (MED) Process

2.1.3. Low Temperature Evaporation (LTE) Desalination Using Waste Heat

As the energy cost component is a major fraction of the desalinated water cost, utilization of waste heat as energy input for seawater desalination is an attractive option. It is one of the eco-friendly ways to produce desalinated water as it does not require chemical pretreatment of feed seawater. Ocean thermal energy can also be utilised for sea water desalination.

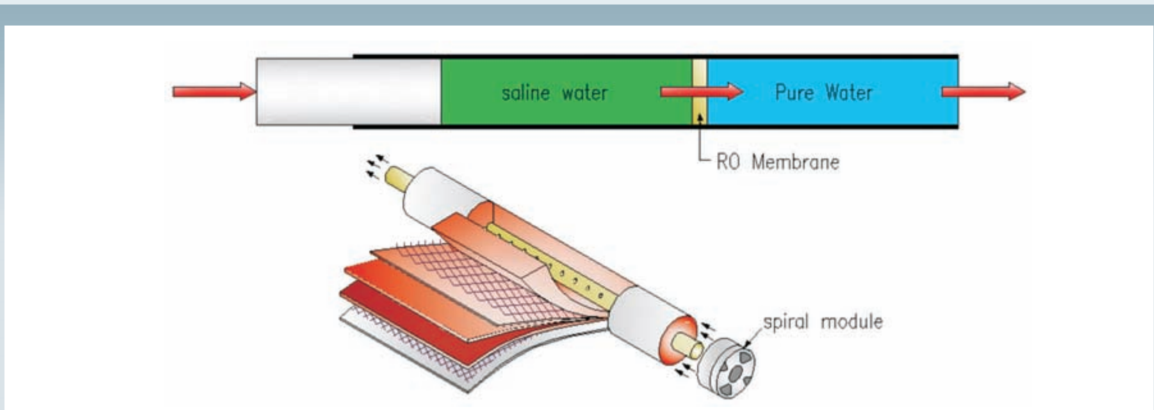
The desalination unit essentially consists of three portions i.e. heater, separator and condenser. In the heater shell, vertical tubes are used. Feed sea water enters the unit at the bottom of the tubes and partly evaporates by the time it comes out from the top. After water and vapour mixture come out of the tubes, the vapour rises through the vertical shell, enters the horizontal tube bundle kept at the top of the vertical shell and condenses around the tubes (which are cooled by sea water flowing inside) producing desalinated water. The product water is pumped out.



LTE Desalination using waste Heat

2.2. Reverse Osmosis (RO)

RO is used for both brackish water and seawater desalination as well as for waste water treatment and water recovery/reuse. A typical RO desalting plant consists of three sections, namely pretreatment section, membrane section and post treatment section. Conventional pretreatment section typically consists of particulate filtration, micron filtration and chemicals additions. Membrane section consists of membrane elements housed in pressure vessels through which pretreated saline water is passed under pressure in excess of its osmotic pressure with the help of a high pressure pump coupled with energy recovery device. The post treatment section consists of lime treatment for pH correction and chlorination for disinfection as required to meet public health standards and to make the water non-corrosive to the water distribution systems. Energy consumption depends on the salt content of the feed water. Development of RO membranes of very high rejection, while maintaining high permeability, has potential to reduce the energy consumption. Development of better energy recovery devices can further reduce the energy consumption. As the success of RO desalination hinges on the proper pre-treatment of the feed water, various membranes could precede RO in order to selectively remove suspended solids (microfiltration), colloids/turbidity & organics (ultrafiltration) and hardness and sulphates (nanofiltration).



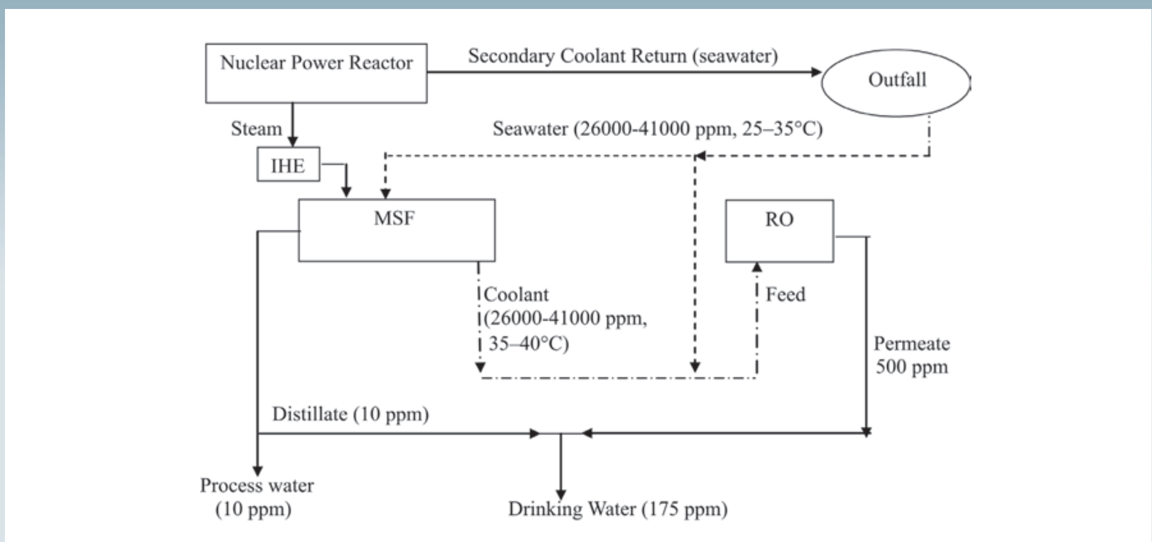
Reverse Osmosis (RO)

2.3. Hybridization

Hybrid thermal/membrane combinations offer several advantages including the use of warm seawater from the thermal plant as feed to RO for having an optimized feed temperature and production of water of different qualities for different uses such as high quality boiler feed make up water, process water and potable water. Combined post treatment, use of common seawater system and brine discharge facility, reduced seawater requirement, sharing the manpower and facilities are other advantages of hybridization.

2.4. Co-generation Using Nuclear Energy

Co-location of desalination and power plants has the benefit of sharing the resources such as common intake of sea water/ outfall and other infrastructural facilities. Dual purpose (power & water) plants have inherent design strategies for better thermodynamic efficiency besides economic optimization. The production of potable water from seawater in a facility in which nuclear reactor is used as the source of energy for the desalination process is termed as nuclear desalination. Electrical and/or thermal energy is used in desalination process on the same site.



Hybrid Desalination System Integrated with Nuclear Power Reactor

3. Challenges in Rural Areas

As water scarcity and contamination problems are more acute in rural areas, implementation of desalination and water purification technologies will help in a big way in providing safe drinking water. But, the various constraints normally encountered in rural areas pose certain limitations on the efficiency and techno-economics of desalination in general.

Power supply in rural areas is a serious concern. Availability of power varies from 8 to 10 hours a day and even the available power supply is highly erratic with crippling voltage fluctuations and sudden power cuts. Hence the total requirement of drinking water for the village needs to be produced in a short span of time when the power is usually available.

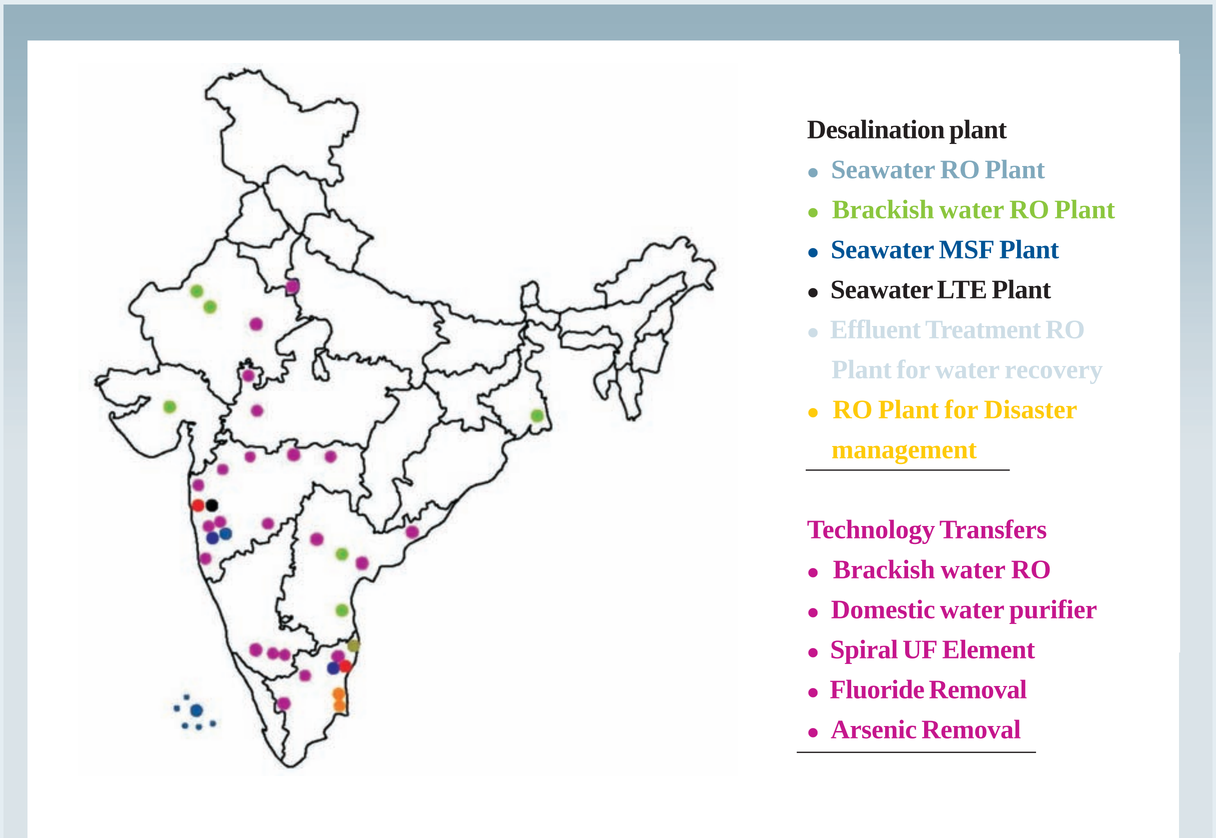
Remoteness and inaccessibility of remote areas pose difficulties in case of equipment failure as skilled manpower and spare parts may not be readily available which results in considerable delay. To deal with such situations the critical moving parts are installed in standby mode and important spare parts are always kept ready.

Due to acute summer and over exploitation of the ground water, the water table goes down, thus affecting the yield and at times rise in salinity. Hence sustenance of the quality and quantity of the product is difficult. Reject water recirculation in the design is the suitable approach which takes care of conserving the ground water resource.

Because of the lack of availability of skilled man power in rural areas the design should take care that minimum human interface is called for. Design should be robust and simple.

4. Role of Department of Atomic Energy (DAE) in Desalination & Water Purification

As a part of the national program to improve the quality of life in our society, BARC has been engaged in research, development and deployment of desalination and water purification technologies for a wide range of applications. It includes sea water RO for coastal areas, brackish water RO in villages for producing safe drinking water, MSF for seawater desalination using low grade steam, LTE using waste heat for seawater desalination. Ultra-Filtration (UF) based water purification for domestic and community use and waste water recycle and reuse. These processes are either used in standalone or hybrid mode to suit the requirement. The technologies have been demonstrated and deployed in different parts of the country and transferred to several parties on non-exclusive basis. BARC has been providing guidance and consultancy to several agencies in this regard. The Department has achieved several milestones in the field of thermal desalination and membrane technologies as given in Annexure I and II respectively.



Deployment of Desalination & Water Purification Technologies by Department of Atomic Energy (as on June 2010)

In case of membrane technology, the Department has come to a level of having full-fledged facilities for indigenous development of membranes & membrane devices, capabilities for design, engineering and consultancy services for installation, commissioning and trouble shooting.

In thermal desalination, efforts are continued to reduce the cost through R&D including technological innovations such as high heat transfer performance, utilisation of low grade and waste heat etc.

BARC has been engaged in several international collaborations dealing with various aspects of desalination and water purification. BARC has signed Memorandum of Understandings (MoUs) for providing consultancy on design, design checkup and trouble shooting of desalination and water recycling plants.

In the larger interest of providing clean water to the people and thereby improving their quality of life, DAE desires to promote wider deployment of these indigenous desalination and water purification technologies. The technical knowhow of these technologies are available through Technology Transfer & Collaboration Division (TTCD) of BARC. The entrepreneur can purchase the appropriate technology which will be transferred on a non exclusive basis.

5. Technologies and Products Developed by BARC

The features of the products and technologies developed are given in Annexure III.

5.1. Membrane Technologies

Reverse Osmosis (RO) and Ultra-Filtration (UF) based systems for different applications have been developed. Work on exploring the role of nano-technology on desalination and water purification also has been taken up.

5.1.1. Brackish Water RO

R&D efforts in BARC has resulted in the development of brackish water desalination technology. Several community level desalination plants of capacities ranging from 5-30 Kilo-Litres/ Day (KLD) have been setup in the rural areas of Rajasthan, Andhra Pradesh and Gujarat producing clean water from brackish water. These reverse osmosis plants are not only capable of desalinating brackish water but are also capable of removing contaminants such as fluoride, arsenic, nitrate etc.

Brackish Water Desalination Plants in Rural Areas (5-30 KLD capacity)

5.1.2. Sea Water RO

BARC has developed the design methodology of Seawater Reverse Osmosis (RO) system and based on the experience gained from the 100 KLD RO plant at Trombay, it has setup a SWRO plant at Kalpakkam which produces 1.8 Million Litres/ Day (MLD) of potable water. A barge mounted desalination plant (50 KLD capacity) for producing drinking water from seawater has also been developed. Such desalination plants are useful for water starved coastal areas. Similar units can also be used for disaster management to provide drinking water in the coastal areas during emergency. For disaster management, desalination plants (2 nos., 5 KLD capacity each) were designed and installed in the Tsunami affected areas of Tamil Nadu. Special care was taken in the design so that the plant can operate under wide range of feed water quality in terms of physical, chemical and biological contaminants with minimal pretreatment.

5.1.3. Development of Membrane and Modules

Indigenous development of membranes for various applications such as brackish water and sea water desalination and water recovery/ reuse from effluents is pursued. Cellulose acetate based membranes developed in tubular and flat sheet configurations were transferred to several parties for

100 KLD SWRO Plant at Trombay

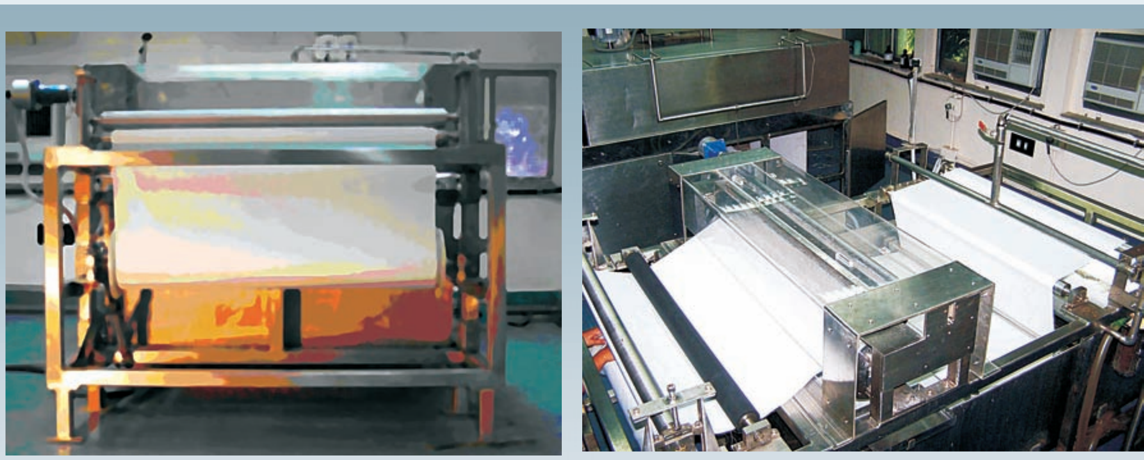
1.8 MLD SWRO Plant at Kalpakkam

commercialization. R&D efforts on membrane manufacturing technology have resulted in the development of Thin Film Composite Polyamide (TFCP) membranes. These are three layered membranes, prepared in two stages. The membranes thus prepared are rolled in spiral configuration using the technology developed in-house. The poly sulfone membrane which is in the ultrafiltration (UF) range, prepared as a precursor for the TFCP has been found to be good for many applications.

5.1.3.1. Back washable UF Spiral Modules

Backwashable spiral element based on poly sulfone UF membranes for delivering sterile water with six (6) log reduction of bacteria and four (4) log reduction of virus has been developed. It is a promising technology for water purification, wastewater treatment and water reuse. These devices with capacity ranging from about 0.5 LPM to 4 LPM can be deployed for community water purification or small-scale industries. As RO pretreatment system also, the unit has been perfected in the Department. It

Barge Mounted Desalination plant (50 KLD capacity) provides an absolute barrier to the particles present in the raw saline water regardless of the system load, operational conditions, or the fluctuations and changes. The unit is back washable either manually or automatic mode. The single step of UF pretreatment can replace the conventional pretreatment system comprising clarifier, coagulant and flocculent dosing coarse media filter and active carbon filters. The other advantages are smaller footprint/ layout area, single step process, modular expandability, less volume of discharged wastes (including sludge and chemicals), simplicity of operation, process automation etc. The technology has been transferred for wider deployment.

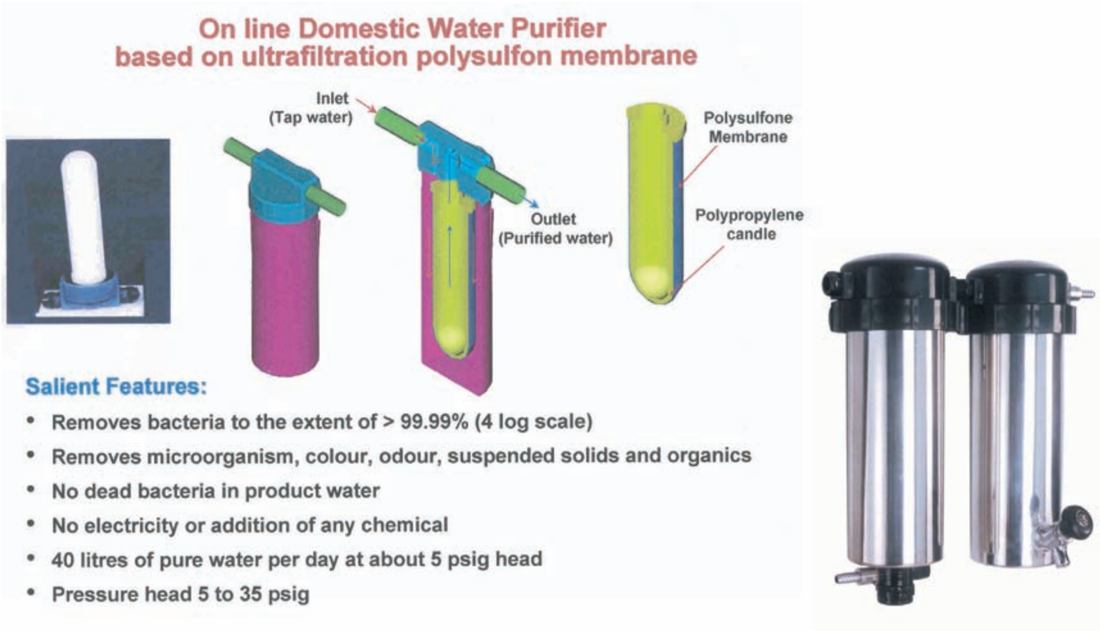


Membrane Casting Machine at BARC

Indigenously Developed Spiral Modules

5.1.3.2. Candle Type UF Water Purification Device

A novel idea of coating poly sulfone on a porous candle resulted in the development of a 'point of use' water purifier. Unlike other devices available in the market which only deactivates the micro-organisms, this device physically eliminates them. This device does not require any electricity or any addition of chemicals. Removal of suspended particulates, color and odor are additional benefits available in these units. A typical unit provides nearly 40 liters of water per day at 3 meters pressure head and can withstand up to 40 psig pressure. These water purifiers of low capacity and zero operating cost are meant to satisfy the domestic need for safe water. The technology has been transferred to eighteen parties for commercial deployment.



Water Purifier Developed by BARC

5.1.4. Spin-off Membrane - Porous Polysulfone Diaphragm as Separator in Electrochemical Processes

The porous polysulfone diaphragms reinforced with non-woven support fabric has been found to be useful as separator in electrochemical processes involving highly acidic solutions for production of various chemicals such as ammonium per sulphate $(NH_4)_2S_2O_8$.. These diaphragms have very high porosity (60-70%) with submicron pore sizes resulting in low electrical resistance in electrolyte solutions and are stable up to 30% H_2SO_4 solution. The production cost of these diaphragms is lower by an order of magnitude compared to presently used nafion membranes with comparable properties. The polysulfone diaphragm can be used as a separator in electrolytic cell.

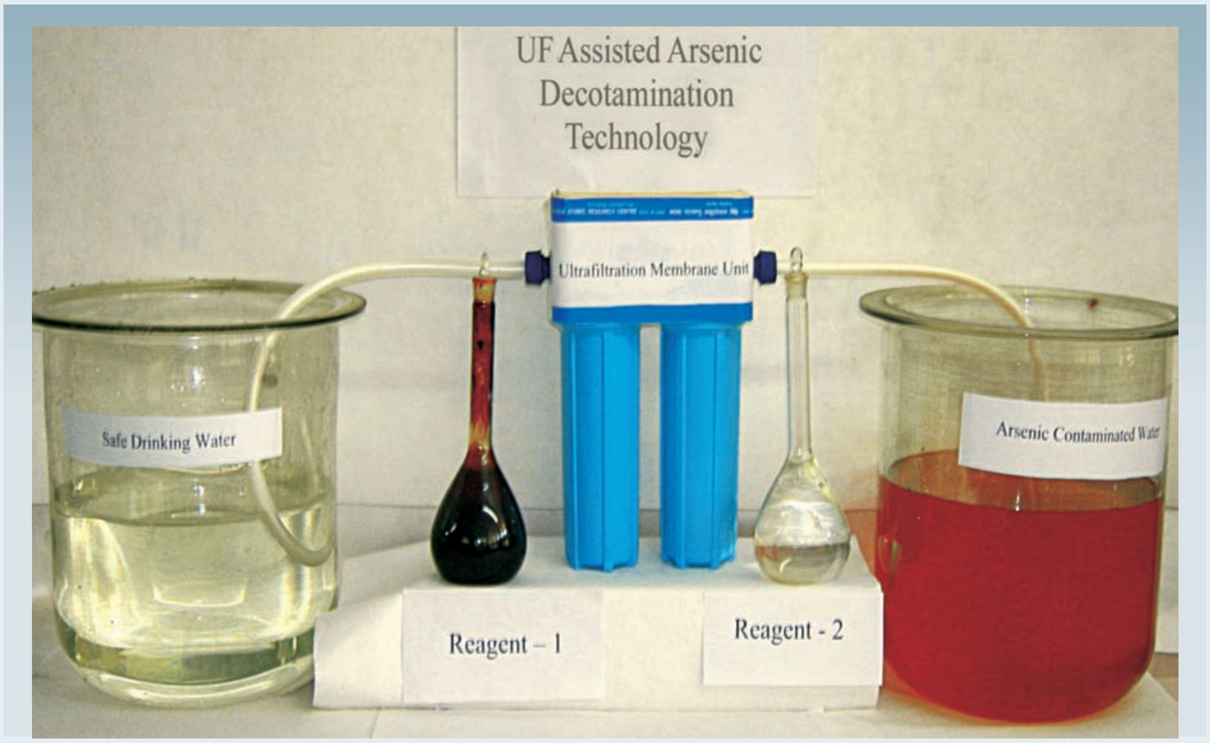
5.1.5. UF Assisted Fluoride Removal System

While the desirable limit of fluoride in water is 1 mg/ litre (ppm), several states in the country have higher fluoride content in water. It causes dental, skeletal and non-skeletal fluorosis. Treatment of fluoride contaminated water by use of alumina column and subsequent polishing by ultrafiltration process ensures efficient removal of fluoride as well as secondary aluminum contamination. A comprehensive technology comprising re-generable alumina followed by ultrafiltration is developed in the Department.

UF Assisted Fluoride Removal System

5.1.6. UF Assisted Arsenic Removal System

The desirable limit for Arsenic in Drinking water is 10 ppb. Arsenic problem is acute in West Bengal, Jharkhand, Bihar and parts of Uttar Pradesh. People in the affected areas suffer from skin rashes. A comprehensive technology comprising iron oxide followed by ultrafiltration is developed in the Department to get rid of arsenic contamination from water.



UF Assisted Arsenic Removal System

5.1.7. UF Assisted Iron Removal System

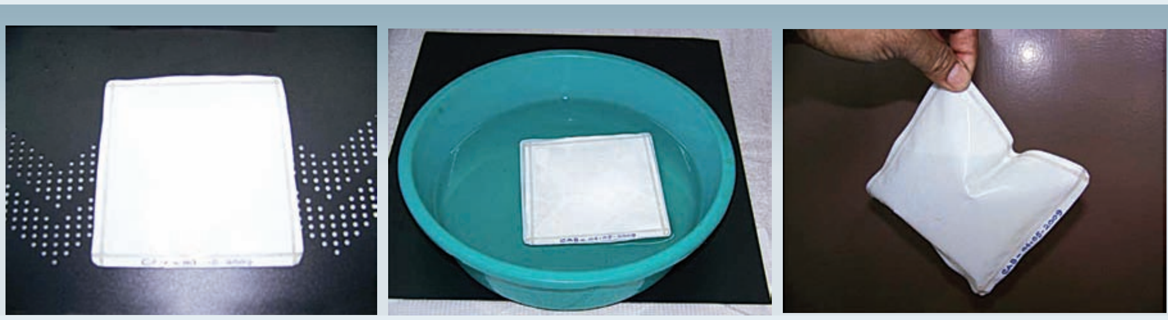
Iron contamination in water is called aesthetic contamination. The presence of iron in water causes red colour, bad smell & taste. The oxidation reaction changes the iron from a soluble form into a less soluble form, thus causing precipitation and accumulation of reddish brown material. The WHO desirable limit of iron content in drinking water is 0.3 ppm. A comprehensive technique comprising oxidation followed by ultrafiltration is developed in the Department which achieved upto 0.1 ppm of iron concentration in product from 20 ppm of feed iron concentration.

UF Assisted Domestic Size Iron Removal System

UF Assisted Community Size Iron Removal System

5.1.8. Membrane Pouch for Providing Sterile Water Solution from Contaminated Water

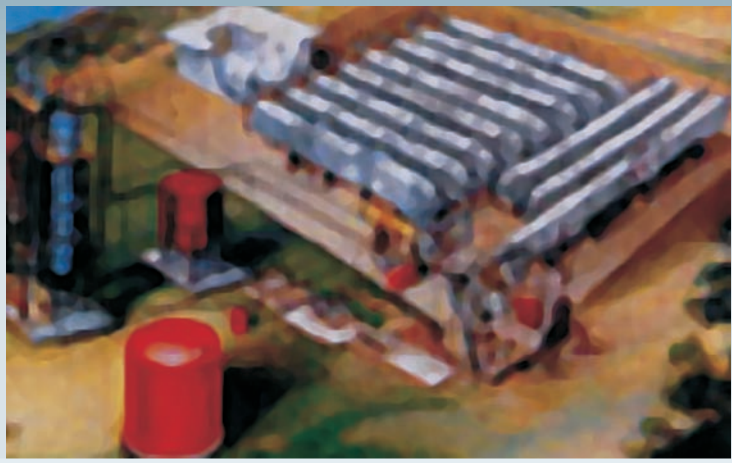
The technology provides a process for the preparation of Membrane Pouch for Providing Sterile Drinkable solution from any biological Contaminated Water. A low molecular weight, water soluble, non-toxic substance having a high osmotic pressure like Oral Rehydration Salt (ORS) mixture, milk powder or any other water soluble and drinkable substance taken inside the pouch. Based on the Osmosis only pure water permeates through the semi permeable membrane and disolves the nutrient salts filled in the pouches. These are easily portable devices used in disaster management conditions like floods, Tsunami, earthquakes etc. and it can be used in any contaminated water.



Water purification through Membrane Pouches

5.2. Thermal Desalination

Thermal desalination processes, except freezing, mimic the natural process of rain. Saline water is heated producing water vapor that in turn condenses to form distilled water. Thermal processes include multistage flash (MSF), low temperature evaporation (LTE) multiple-effect distillation (MED) etc. Thermal processes are normally used for seawater desalination. They are capable of producing high purity water which is suited for high end industrial use.



MSF Plant at Trombay (425 KLD capacity)

Salient features of the different thermal desalination technologies developed and demonstrated by BARC are given as follows.

5.2.1. Multi-Stage Flash (MSF)

BARC has developed MSF technology based on long tube design requiring less energy consumption as compared to conventional MSF. Based on the experience gained from the 15 KLD desalination experimental facility and 425 KLD MSF pilot plant at Trombay, a 4.5 MLD MSF unit was designed and built as a part of the 6.3 MLD Hybrid MSF-RO plant.

5.2.2. LTE Desalination using Waste Heat

A 10 KLD LTE desalination plant using the waste heat of 500 KVA diesel generator was installed and commissioned in one of the islands of Lakshadweep under BARC consultancy for producing desalinated water from seawater. Such plants are ideally suitable for coupling with power plants where abundant waste heat is available. These plants can also produce high purity distilled quality water from high salinity water or seawater for the rural areas where waste heat from Diesel Generator (DG) sets/ solar energy is available.

Next Generation LTE-CT Plant at Trombay

(50 KLD capacity)

EDI unit (capacity: 5000 LPD)

An LTE system producing 50 KLD distilled water from seawater with innovative design features to reduce the raw water requirement by order of magnitude is also developed in BARC.

In order to produce ultra-pure water (0.1 µS/cm conductivity) for high end applications, Electro-De-Ionization (EDI) is integrated with LTE. EDI is a combination of Electro dialysis (ED) and Ion exchange (IE). The product from the EDI unit (5 KLD capacity) is supplied to the various facilities in BARC (Trombay) on demand.

5.2.3. Multi-Effect Distillation (MED)

A 1000 litres/ day Horizontal Tube Thin Film (HTTF) desalination unit has been earlier developed and operated for basic studies on boiling heat transfer and hydrodynamics over a wide range of temperatures for having data bank for designing efficient MED desalination plants. Based on R&D work, a MED-MVC desalination plant (50 KLD capacity) was designed and put up. The special features of this type of plant are the HTTF evaporators having high heat transfer efficiency, less pumping power requirement and lower raw water consumption. MED-MVC requires only electrical power for seawater desalination. This plant also uses a novel Spray Enhancing Demisters (SED) to produce ultra high purity water.

MED-VC Desalination Plant

6. Desalination using Nuclear Energy

Desalination is an energy intensive process. Production of potable water in a facility in which nuclear reactor is used as the source of energy for the desalination process is termed as nuclear desalination. Electrical and /or thermal energy from the reactor is directly used by the desalination plants. An isolation loop is provided between the nuclear reactor and the desalination plant for ensuring no radioactive contamination and high protection of desalinated water. Co-location of desalination and power plants has benefits of sharing the infrastructural facilities as in the case of hybrid plants. Dual purpose plants generating power & water have inherent design strategies for better thermodynamic efficiency besides economic optimization. India is among very few countries having experience in different coupling aspects of a nuclear desalination plant. Interest in using nuclear energy for producing desalinated water is growing world wide. This has been motivated by wide varieties of reasons such as economic competitiveness of nuclear energy to energy-supply diversification etc.

6.1. Hybrid System

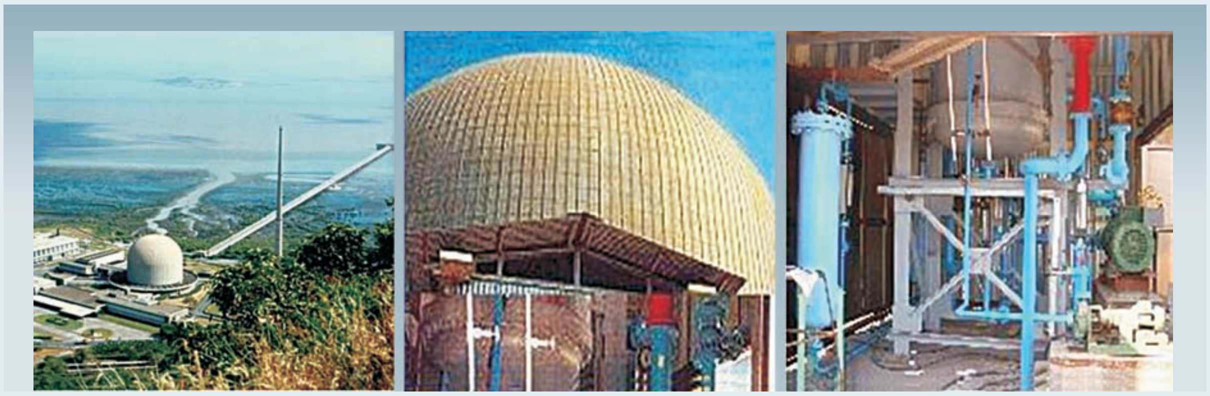
Nuclear Desalination Demonstration Plant (NDDP) at Kalpakkam based on hybrid technology consists of a hybrid MSF-RO desalination plant of 6.3 million litres per day (MLD) capacity (4.5 MLD MSF and 1.8 MLD RO) coupled to Madras Atomic Power Station (MAPS), Kalpakkam. The requirements of seawater, steam and electrical power for the desalination plant are met from MAPS. It is the largest nuclear desalination plant based on hybrid technology in the world. MSF section is designed for high efficiency giving high Gain Output Ratio (GOR). It has 39 flash stages producing distilled quality water for high end applications in industries. RO section incorporates necessary pretreatment and an energy recovery system. It operates at relatively lower pressure and employs lesser pretreatment chemicals because of relatively clean feed seawater from MAPS outfall. RO produces potable quality water. Product water from MSF and RO can be blended to provide better quality drinking water.

Nuclear Desalination Demonstration Plant (NDDP)

Hybrid RO-MSF Nuclear Desalination Plant at Kalpakkam (6.3 MLD capacity)

6.2. LTE System utilising Nuclear Waste Heat

In order to demonstrate the utilisation of nuclear waste heat for seawater desalination, a 30 KLD LTE desalination plant was coupled to a nuclear research reactor for utilizing a part of its waste heat for producing desalinated water from seawater to meet the make-up water requirement of the reactor. An intermediate heat exchanger (IHE) is incorporated between nuclear reactor and the desalination plant to ensure no radioactive contamination and high protection of desalinated water.



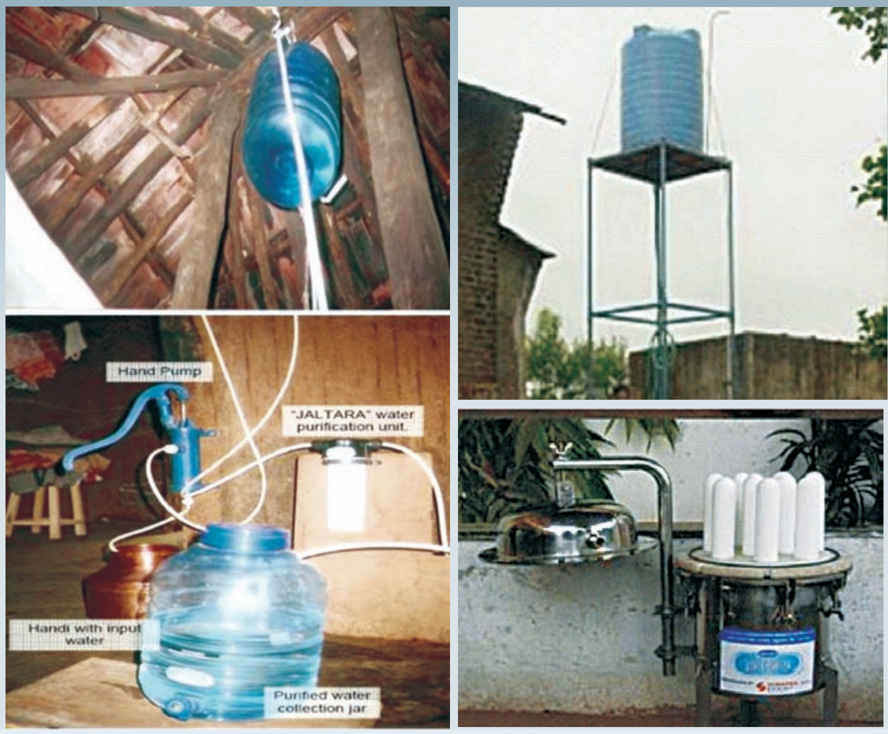
LTE Desalination Plant Using Nuclear Waste Heat

7. Desalination & Water Purification Systems for Rural Areas

Water scarcity and contamination problems are more acute in rural areas along with infrastructural constraints including less or no electric power supply. These communities are often drinking water of substandard quality, as they do not possess appropriate technology to purify the water.

7.1. Rural Adaptation of UF based Water Purification Technologies

Rural adaptation of UF based water purification technologies for providing safe drinking water in villages is shown in the picture given below. The required minimum head is created by keeping the tanks at an elevation and filling the contaminated water in the tanks with the help of hand pumps. Multiple candles system also is designed for community level water purification.



Domestic and Community Level Water Purification Units

7.2. Solar Desalination & Water Purification Systems

Solar desalination becomes an attractive alternative for remote and rural areas where, grid electricity is not available. It is reported that, there are thousands of Indian villages which cannot be connected to the grid power network, due to their remoteness. Also, power production utilizing environment friendly renewable energy sources is the solution for the issue of climate change. The most widely used renewable energy source is the sun. The source of solar energy is inexhaustible and it is free. No harmful gases are emitted such as nitrogen oxide, mercury, carbon dioxide, or sulphur dioxide. In addition, there are various financial incentives that are offered by the government for the production of solar power. Electricity is locally produced from sunlight with the help of photovoltaic (PV) panels. Solar PV-powered desalination systems are suited for small community level plants considering the techno-economic viability.

7.2.1. Solar PV based Water Treatment Systems

BARC is engaged in developmental work on desalination systems based on solar energy. Small and community level RO and UF units are developed for producing safe drinking water.

7.2.1.1. Small brackish water RO & UF units

The solar RO unit (10 LPH) contains a cartridge pre-filter and a spirally wound RO membrane element. The feed water is passed through the membrane with the help of a DC pump directly connected to the PV panels, without any batteries. The unit can be normally operated for 9 to 10 hrs on sunny days. The UF unit (50–100 LPH) consists of candle and capillary type filters and is operated in the same way.

PV Based Small Scale RO & UF Units

7.2.1.2. Community size RO plant

Water conservation becomes an issue when the natural recharge rate of the source is slow as in the case of ground water. For this reason, a significant fraction of the concentrate stream (which otherwise is rejected) is recycled back, so that fresh feed as well as discharge volumes can be minimized. In the case of low saline (1000 ppm) brackish water, the concentrate also can be used for non-potable purposes, if the product recovery is kept minimum. This would prevent wastage of water by way of reject disposal.

Community Level RO Plant along with PV Panels (250 LPH)

8. Consultancy

BARC has expertise in design, engineering, installation, erection, commissioning and troubleshooting of desalination/ effluent treatment plants and the same is offered to outside parties through consultancy. Design consultancy has been provided to National Institute of Ocean Technology (NIOT) for a 100 KLD Low Temperature Desalination System utilising ocean thermal energy gradient. It was installed by NIOT at Lakshadweep. BARC has provided consultancy to Bharat Heavy Electrical Limited (BHEL) for large size thermal desalination plants. Consultancy for the troubleshooting of membrane based effluent treatment plant for recovery of water also has been provided to Bharat Petroleum Corporation Limited (BPCL).

9. Recovery of Valuables from Reject Brine of Desalination

The concentrated stream (brine) rejected from the desalination plants is a source of many valuable chemicals. Some of these elements are scarce and expensive. There is thus a strong motivation in recovering these elements from the reject brine of a desalination plant. This also adds value to a desalination plant apart from making it more environment friendly.

10. Services

Water quality monitoring is an important aspect and has a significant bearing on the design of a suitable desalination system. The department has a well-equipped laboratory to analyze the quality of the raw water available to check its potability as well as to identify the specific contaminant present in the saline water.

11. Transfer of Technical Knowhow

BARC offers knowhow of the indigenously developed technologies/ products to interested parties on non-exclusive basis. The details of the technologies offered are mentioned in the website www.barc.gov.in.

11.1. Who Can Apply

Interested parties with engineering and scientific knowledge, good financial background and technical and infrastructural capability are preferred.

11.2. How To Apply

Send your Technology Transfer Application Form (as per the format given in Annexure IV) duly filled and signed along with a Demand Draft of Rs. 500 (for Indian Entrepreneurs) and USD 50 (for foreign entrepreneurs) drawn in favor of 'Accounts Officer BARC' as application processing fee to the following address.

Technology Transfer & Collaboration Division (TT&CD),

Bhabha Atomic Research Centre,

Trombay, Mumbai 400 085,

India

Phone : +91-22-25593897/ +91-22-25593648

Fax : +91-22-25505151/ +91-22-25519613.

ANNEXURE - I

Milestones in Thermal Desalination

	Technologies & Plants	Year
1.	30 kilo-litres/day (KLD) Low Temperature Evaporation (LTE) seawater desalination plant using waste heat.	1985
2.	425 KLD MSF plant for seawater desalination.	1990
3.	1 KLD Thermocompression (TC) desalination unit for seawater desalination.	1997
4.	10 KLD LTE desalination plant using waste heat for seawater desalination at Lakshadweep.	1997
5.	1 KLD Horizontal Tube Thin Film (HTTF) desalination unit for MED.	2002
6.	30 KLD Low Temperature Evaporation (LTE) desalination unit using waste heat of nuclear reactor for seawater desalination.	2004
7.	50 KLD Multi-Effect Distillation-Vapor Compression (MED-VC) seawater desalination plant.	2006
8.	50 KLD Low Temperature Evaporation (LTE) seawater desalination plant with Cooling Tower.	2007
9.	4.5 MLD MSF plant at Kalpakkam as a part of NDDP.	2008
10.	Hybrid LTE-EDI system for producing ultra-pure water from seawater.	2010

ANNEXURE - II

Milestones in Membrane Technology

	Technologies & Plants	Year
1.	Technology Transfer of tubular membrane development for commercial utilization.	1983
2.	2 x 30 KLD brackish water RO plants for providing drinking water in villages of Andhra Pradesh & Gujarat.	1984
3.	Technology Transfer of plate & frame module development for commercial utilization.	1985
4.	50 KLD Reverse Osmosis (RO) unit for industrial effluent treatment at RCF, Mumbai.	1986
5.	15 KLD Reverse Osmosis-Demineralisation (RO-DM) plant at VECC, Kolkata for production of low conductivity water.	1994
6.	26 KLD NF plant for a pharmaceutical industry.	1998
7.	30 KLD brackish water RO plant for providing drinking water in village at Barmer, Rajasthan.	1998
8.	100 KLD Seawater Reverse Osmosis (SWRO) plant at Trombay.	1999
9.	1.8 MLD SWRO plant at Kalpakkam as a part of NDDP.	2002
10.	Technology Transfer of Domestic water purifier.	2002
11.	30 KLD RO plant providing drinking water in a village at Jodhpur, Rajasthan.	2003
12.	5 KLD BWRO plant for providing drinking water during Tsunami at Tamil Nadu.	2004-05
13.	Development of Thin Film Composite (TFC) Polyamide based membrane casting assembly.	2006
14.	50 KLD Barge Mounted seawater desalination plant for water scarce coastal and remote areas.	2007
15.	Technology Transfer of Back-washable Spiral element for commercial utilization.	2008
16.	Technology Transfer of Arsenic Removal from Drinking Water by physicochemical process.	2009
17.	Technology Transfer of Fluoride Removal from Drinking Water by physicochemical process.	2009
18.	Technology Transfer of Iron Removal from Drinking Water by physicochemical process.	2010
19.	Commissioning of solar RO unit for brackish water desalination.	2010
20.	Technology Transfer for Preparation of Composite Polyamide Reverse Osmosis (RO) membrane for Brackish Water Desalination.	2010

ANNEXURE - III

Desalination & Water Purification Technologies and Products

Developed by BARC- Technical Features

Water quality problems exist nearly in all the parts of our country. It is estimated that about 70 – 80% of health problems can be traced to deficiency in the water quality. Micro-biological contamination is a common problem in most of the parts. Specific regions have some predominant geogenic based contaminants. Iron, a major contaminant, is predominant in north eastern States while arsenic is a problem in the eastern part. It is disturbing to note that arsenic contamination is spreading across the gangetic plain extending to Punjab. Fluoride contamination is present in a number of states including western, south east and northern states. Salinity in the ground water is increasing day by day and becoming a significant problem in majority of states due to overexploitation of ground water in the inland areas and seawater ingression in the coastal areas. Technological intervention has become a necessity for a reliable & sustainable availability of safe drinking water.

Bhabha Atomic Research Centre (BARC) has developed several water purification devices and desalination technologies, as a part of its research & development efforts towards the betterment of the society. These technologies or products are backed with robust design concepts and pilot plant studies, which can cover the needs of households, communities, industries and metropolis. Know how of products/ components/technologies and services available in the field of water treatment can be broadly classified based on their applications as,

1. Water purification systems for the removal of microorganisms, turbidity & toxic contaminants such as, As, Fe, F etc for producing safe drinking water.
2. Desalination Units for the removal of salinity using membrane process or thermal desalination for producing pure water for drinking or industrial uses.
3. Effluent treatment plants based on UF & RO for recovery of water for reuse or for safe disposal.
4. Units which can operate without electricity (domestic UF) or operating on solar power (UF & RO), which are most suited for remote and rural areas.

The know-how of these technologies/ products has been transferred to several parties for wider deployment in a commercially viable manner and is available on non-exclusive basis through technology transfer. Similarly, services in design, engineering, installation, commissioning, operation and trouble-shooting of brackish water & seawater desalination and effluent treatment plants are available through consultancy.

An entrepreneur interested in the manufacturing of the point-of-use UF based candle type domestic water purification device would require an investment of about Rs. 10.00 lakh (Rupees ten lakh only). Bigger products for community level application, such as back-washable spiral UF element and RO membrane require higher investment in the order of about Rs. 25 to 50 lakh. The overall cost of water produced would be about 1-2 paise per litre for water purification, 3-5 paise for brackish water desalination and 5-10 paise for seawater desalination. It should however be noted that these cost figures are only indicative and would vary depending on the location, capacity, energy cost, extent of automation etc.

The technical features and detailed information with respect to the technologies and products developed by BARC are given in the following pages. Details include objective, type of process used, features, capacity range, indicative unit cost, O&M cost and specific requisites (if any) for deployment etc.

1. Name of the Technology : UF based Domestic Water Purifier

S. No	Items	Specific Information
1	Objective of the Unit	For the removal of turbidity, colloids and microbiological contaminants
2	Name of the process	Ultrafiltration (UF)
3	Features of the technology	• Suitable for domestic application • Operated under tap water head (> 3 m) • Max. Operable pressure : 2 kg/cm^2 • Filter life: Minimum 3 yrs (typical)
4	Capacity	40-100 litres per day
5	Typical Unit cost	Rs. 2000-5000
6	O & M cost (Rs. per cubic meter of product water)	Negligible
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	Indoor location
	b) Electrical power requirement	None
	c) Necessity of specialized manpower	Nil. The filter candle can be easily cleaned physically

2. Name of the Technology : Back-washable Spiral Wound Ultrafiltration (UF) Element

S. No	Items	Specific Information
1	Objective of the Unit	Purification of water for the removal of suspended/colloidal and biological contaminants at higher capacities
	Name of the process	Ultrafiltration (UF)
2 3	Features of the technology	• for community or industrial level applications • Can replace conventional filtration systems like sand filter and cartridge filter • Back washable in auto/manual mode
	Capacity	Modular in nature. Single unit capacity varies from 1000-7000 LPD depending on element sizes
4	Approximate Capital cost (Rs./unit) O & M cost	Rs. 6000 – 40,000 depending upon size and capacity
5	Any specific pre-requisites for installation of the unit	Less than 1 paise per litre
6	a) Open space/shed required for installation of the unit	Require about 2.0 sq.m of footprint area excluding storage tanks. Small units require less space.
	b) Electrical power requirement	Only for pumping the water at 2 bar pressure
	c) Necessity of specialized manpower	Local manpower with training on O & M

3. Name of the Technology : Membrane Assisted Fluoride Removal

S. No	Items	Specific Information
1	Objective of Technology	Treatment of fluoride-contaminated ground water to obtain safe drinking water (below WHO limit of 1 ppm)
2	Name of the process	Ultrafiltration (UF) membrane assisted alumina adsorption process
3	Features of the technology	• Fluoride ion in feed that can be treated 10 ppm (max) • Regeneration cycle of alumina bed: 10 Nos. • Product water free from aluminum (less than 0.1 ppm), biological and colloidal contaminants
4	Capacity (range available)	50-5000 litres per day per unit
5	Approximate capital cost (Rs. /unit)	Rs. 3000 and above
6	O & M cost	< 1 paise per litre. May vary depending on the concentration of fluoride in feed water
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	Small units up to 100 LPD can be installed as a wall mounted unit. Bigger units may require about 2.0 sq.metre of footprint area excluding storage tank.
	b) Electrical Power requirement	< 0.1kW
	c) Necessity of specialized manpower	Local manpower with proper training

4. Name of the Technology : Membrane Assisted Arsenic Removal

S. No	Items	Specific Information
1	Objective of Technology	Treatment of Arsenic-contaminated ground water to obtain safe drinking water (below WHO limit of 10 ppb)
2	Name of the process	Ultrafiltration (UF) membrane assisted sorption process
3	Features of the technology	• Arsenic ion in feed that can be treated : 500 ppb (max) • Product water contains less than 10 ppb arsenic concentration. • Product water free from biological and colloidal contaminants
4	Capacity (range available)	50-5000 litres per day per unit
5	Approximate capital cost (Rs./unit)	Rs. 3000 and above
6	O & M cost	< 1 paise per litre. May vary depending on the concentration of arsenic in feed water
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installa tion of the unit	Small units up to 100 LPD can be installed as a wall mounted unit. Bigger units may require about 2.0 sq.metre of footprint area excluding storage tank.
	b) Electrical Power requirement	< 0.1kW
	c) Necessity of specialized manpower	Local manpower with proper training

5. Name of the Technology : Membrane Assisted Iron Removal

S. No	Items	Specific Information
1	Objective of Technology	Treatment of Iron contaminated ground water to obtain safe drinking water (below WHO limit of 0.3 ppm)
2	Name of the process	Ultrafiltration (UF) membrane assisted oxidation process
3	Features of the technology	• Iron (Ferrous ion) in feed that can be treated : 20 ppm (max) • Guaranteed product quality: Iron below 0.1 ppm • UF filtered product water is free from biological and colloidal contaminants too
4	Capacity	50-5000 litres per day / unit
5	Approximate Capital cost (Rs./Unit)	Rs. 3000 and above
6	O & M cost	< 1 paise per litre
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	Small units upto 100 LPD can be installed as a wall mounted unit. Bigger units may require about 2.0 sq. metre of footprint area excluding storage tank.
	b) Electrical power requirement	About 0.1kW for 5 KLD.
	c) Necessity of specialized manpower	Local manpower with proper training

6. Name of the Technology : Membrane Pouch for Providing Sterile Water Solution from Contaminated Water

S. No	Items	Specific Information
1	Objective of Technology	To provide safe sterile drinkable water from contaminated water
2	Name of the process	Osmosis
3	Features of the technology	• Produces complete sterile water. • Easily portable device that can be used in disaster management conditions like floods,Tsunami etc. • It can be used in any contaminated water.
4	Capacity	A 15cm x 15cm size membrane pouch containing 5gm of Oral Rehydration salt (ORS) powder can produce 200ml sterile water solutions in 3-3.5 hrs. time.
5	Approximate Capital cost (Rs./Unit)	Rs. 25/- per pouch
6	O & M cost	Nil
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	Nil
	b) Electrical power requirement	Nil
	c) Necessity of specialized manpower	Nil

7. Name of the Technology : Brackish water Reverse Osmosis (BWRO)

S. No	Items	Specific Information
1	Objective of the technology	To desalinate brackish water so as to produce good water for domestic or industrial uses.
2	Scope of service	Process design, system engineering and commissioning procedures for setting-up reverse osmosis desalination systems.
3	Features of the technology	• Conserves ground water sources. • UF pretreatment for reliability. • Product post treatment for palatability • Reject management with respect to harmful contaminants such as fluoride, arsenic etc. • Site specific Design
4	Capacity	10 – 50 KLD
5	Approximate capital cost (Rs. /unit)	Depends on feed water quality and local infrastructure. Approx Rs 50 per LPD capacity
6	O & M cost	1 paise per litre (min). Will vary depending on capacity and power cost.
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	About 50 sq.m for 10 KLD
	b) Electrical Power requirement	1 kWh/ KL of product water (min)
	c) Necessity of specialized manpower	Local manpower with proper training

8. Name of the Technology : Sea Water Reverse Osmosis (SWRO)

S. No	Items	Specific Information
1	Objective of the technology	To desalinate seawater so as to produce good water for domestic or industrial uses.
2	Scope of service	Process design, system engineering and commissioning procedures for setting-up sea water reverse osmosis desalination systems
3	Features of the technology	• UF pretreatment system for reliability. • Post treatment system for palatability and acceptability. • Site specific Design
4	Capacity	1 MLD and above
5	Approximate capital cost (Rs./unit)	Depends on feed sea water quality and local infrastructure and logistics. About Rs 100 per LPD capacity within the battery limits
6	O & M cost	4 paise (min). Will vary depending on capacity, power cost and local conditions.
7	Any specific pre-requisites for installation of the unit	
	a) Open space/shed required for installation of the unit	Foot print of about 5000 sq.m for 1 MLD.
	b) Electrical Power requirement	5 kWh/ KL of product water (min). Sensitive to feed quality and other local design constraints.
	c) Necessity of specialized manpower	Local manpower with proper training

9. Name of the Technology : Multi-Stage Flash (MSF)

S. No	Items	Specific Information
1	Objective of the technology	To produce distilled quality water from seawater
2	Scope of service	Know-how and consultancy services (process design, system engineering, procurement services) in setting up MSF Desalination Plant
3	Features of the Technology	• Uses low grade Steam for producing distilled quality water • Specific Energy Consumption : Less than 3 kWh/m^3 & Steam 0.15T/hr (@ 2 bar pressure) per/ m^3 of desalinated water
4	Capacity	Large capacity
5	Approximate Capital Cost (Rs/unit)	About Rs 75 per LPD capacity (Base Year 2007) at battery limits
6	O & M Cost	5-10 paise/lit
7	Any Specific Pre-requisites for installation of the unit	
	a) Open Space/shed required for installation	30,000 sq. m for 4.5 MLD plant
	b) Electrical Power Requirement	650 kW for 4.5 MLD plant
	c) Steam Requirement	21 T/hr @ 2 bar
	d) Necessity of Specialized Manpower	Local manpower with proper training

10. Name of the Technology : Multi-Effect Distillation- Mechanical Vapor Compression (MED-MVC)

S. No	Items	Specific Information
1	Objective of the technology	To produce distilled quality water from seawater
2	Scope	Know how and consultancy services (process design, system engineering, procurement services) in setting up MED-MVC Desalination Plant
3	Features of the Technology	• Uses electricity alone for producing distilled quality water • High Speed Mechanical Vapor Compressor is used • Totally automated PLC-Scada based System for Startup, shutdown and normal operation of the plant.
4	Capacity	50 KLD – 100 KLD
5	Approximate Capital Cost (Rs/unit)	Rs. 200 per LPD (Base Year 2007) at battery limits
6	O & M Cost	5-10 paise/lit (approx) depending on site conditions
7	Any Specific Pre-requisites for installation of the unit	
	a) Open Space/shed required for installation	150 sqm. for 50 KLD to 200 sqm for 100 KLD
	b) Electrical Power Requirement	60 - 100kW (Connected Load)
	c) Necessity of Specialized Manpower	Local manpower with proper training

11. Name of the Technology : Multi-Effect Distillation-Thermo Vapour Compress (MED-TVC)

S. No	Items	Specific Information
1	Objective of the technology	To produce distilled quality water from seawater
2	Scope	Know how and consultancy services (process design, system engineering, procurement services) in setting up MED-TVC Desalination Plant
3	Features of the Technology	• Uses steam for producing distilled quality water • High Performance Ratios are obtained • Reduced Condenser cooling water requirement
4	Capacity	50 KLD onwards (Higher Capacities are beneficial)
5	Approximate Capital Cost (Rs/unit)	Rs. 200 per LPD (Base Year 2007) at battery limits
6	O & M Cost	5-10 paise/lit (approx) depending on site conditions
7	Any Specific Pre-requisites for installation of the unit	
	a) Open Space/shed required for installation	200 sqm. for 50 KLD
	b) Electrical Power Requirement	25 kW - Connected Load
	c) Thermal Power	Steam of 5 bar & above
	d) Necessity of Specialized Manpower	Local Manpower can be trained.

12. Name of the Technology : Low Temperature Evaporation-with Cooling Tower (LTE-CT)

S. No	Items	Specific Information
1	Objective of the technology	To produce distilled quality water from seawater
2	Scope	Know how and consultancy services (process design, system engineering, procurement services) in setting up LTE-CT Desalination Plant
3	Features of the Technology	• Uses steam / hot water for producing near distilled quality water • Reduced Condenser cooling water requirement
4	Capacity	50 KLD – 500 KLD
5	Approximate Capital Cost (Rs/unit)	Rs. 200 per LPD at battery limits
6	O & M Cost	2-10 paise/lit (approx) depending on site conditions
7	Any Specific Pre-requisites for installation of the unit	
	a) Open Space/shed required for installation	100 sqm. for 50 KLD to 400 sqm for 500 KLD
	b) Electrical Power Requirement	20 - 400kW (Connected Load)
	c) Necessity of Specialized Manpower	Local Manpower can be trained

13. Name of the Technology : Low Temperature Evaporation (LTE) utilizing Waste Heat

S. No	Items	Specific Information
1	Objective	To produce distilled quality water from seawater
2	Scope	Know how and consultancy services (process design, system engineering, procurement services) in setting up LTE Desalination Plant
3	Features of the Technology	• Uses waste heat in form of hot water/ low quality steam as energy source for producing near distilled quality water
4	Capacity	10 KLD - 500 KLD
5	Approximate Capital Cost (Rs/unit)	Rs. 200 per LPD at battery limits
6	O & M Cost	2-10 paise/lit (approx) depending on site conditions
7	Any Specific Pre-requisites for installation of the unit	
	a) Open Space/shed required for installation	50 sqm. for 30 , KLD to 400 sqm for 500 KLD
	b) Electrical Power Requirement	20 - 400kW (Connected Load)
	c) Thermal Power	Process Waste Heat
	d) Necessity of Specialized Manpower	Local Manpower can be trained

ANNEXURE-IV

Government of India

BHABHA ATOMIC RESEARCH CENTRE
TECHNOLOGY TRANSFER AND COLLABORATION DIVISION

Application Form for Technology Transfer from BARC

1. Name of the Technology applied for :
2. Name of the party/legal entity with contact details :
3. Name of the applicant, nationality & contact details :
4. Details of Registration as an industry/legal entity (copy of certificate to be enclosed)
5. Address of works & Registered office premises :
6. State full names and full addresses of persons having direct financial interest (applicable for proprietary and partnership firm) :
7. Details of the manufacturing experience, qualifications and experience of party and partners, if any, with details of the technical expertise available to show that the party can handle technical aspects of production, quality control and marketing (Use separate sheets)
8. Financial background with latest copy of audited annual report attached :
9. Name and address of the Bankers :
10. Production capacity plan & space available for the proposed production work :

11 Marketing plan and estimated market potential :

12. Any other information to substantiate technical and financial competence of the party
13. Details of past interaction / association with DAE/BARC or any Indian Organization

:

(Separate sheets may be enclosed if the space provided is insufficient. Application with incorrect and incomplete information will not be considered)

I / We ____request that I/We may be considered for granting technical know-how for the production of ____________________________. I / We assure that all the information provided by me /us on this form is true to best of my/our knowledge, and on the basis of this information any decision taken by Bhabha Atomic Research Centre shall be accepted by me/us. I / We also undertake to furnish any further information required in this connection. Please find enclosed a Demand Draft (non-refundable) / Bankers cheque No. _________ dated _________ of Rs. 500/- (for Indian entities) or US $50/- (for foreign entities) drawn in favour of "Accounts officer, BARC" as application processing fee.

Date : .... Signature ....

Place : .... Name ....

& Office seal

To

Technology Transfer and Collaboration Division,

Bhabha Atomic Research Centre, Trombay,

Mumbai. - 400085, India.

Tel : +91-22-25593897

Fax : +91-22-25505151 / 25519613

Note:

1. Application Processing Fee
   a. Rs. 500/- for Indian entities
   b. US $ 50/- for foreign entities
2. Each technology transfer application must be enclosed with the Demand draft/ Banker's cheque for application processing fee drawn in favor of "Accounts Officer, BARC" and must be sent to Head, Technology Transfer and Collaboration Division, BARC.
3. **Technology Transfer fee will be charged separately** to the **selected party** accepting the technology.
4. Applications **without processing fee will not be considered** for Technology Transfer. Please note that this is only an application processing fee and does not confer any rights for Technology Transfer.
5. Foreign applicants may please note that their application will be considered subject to clearance from statutory bodies.

For further details please contact:

Prof. (Dr.) P. K. Tewari

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Bhabha Atomic Research Centre

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